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A PORTABLE VARIABLE-RATE SPRAYER FOR PLOT USE

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A PORTABLE VARIABLE-RATE SPRAYER FOR PLOT USE[1]

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A wheel-mounted sprayer designed to deliver a logarithmic or variable-dosage pattern of chemical treatment of plots was first reported by Pfeiffer and coworkers. (5).[3] Danielson and Wester (1) determined effective rates of herbicides applied to certain cole and vegetable crops by this kind of sprayer. These workers later confirmed their findings by randomized plot tests. They concluded that a sprayer of this type was advantageous for certain experiments in weed control. Adaptations of the original equipment described by Pfeiffer and coworkers (5) have been found equally effective for several uses (2, 3, 4). These wheel-mounted sprayers employ an engine-powered mixer in the concentrate tank to provide instantaneous mixing of diluent and concentrate liquids. Thus, the rate of application decreases as the plot is sprayed.

A portable variable-rate sprayer for plot use was needed. This paper describes a variable-rate sprayer that utilizes a specially designed mixing manifold that weighs only a fraction as much as wheel-mounted sprayers. This sprayer is easily portable by one man and is adapted to spraying chemicals at variable rates on plots on ditchbanks and ditchbottoms, in rocky, hilly, or brushy areas, and in other places where wheel-mounted sprayers cannot operate.

MATERIALS AND CONSTRUCTION

The variable-rate sprayer developed in this experiment (figs. 1, 2, and 3) consists of the following components:

1. A stainless steel, 3-gallon knapsack spray tank for diluent. This tank is equipped with a pressure regulator, a pressure gage, and an air valve for filling the tank with air.

2. A metal spray can of 1-liter capacity for the concentrate, attached by a steel band to the diluent tank.

3. A pressure-regulating valve on the diluent tank, which releases the diluent liquid into the concentrate tank at a constant pressure. This pressure moves the liquid through the concentrate tank and out through the spray nozzle.

4. A 1/4-inch pipe manifold, which injects the diluent into the concentrate tank from the diluent and air-storage tank. This pipe has fourteen 1/16-inch holes drilled on four sides of the pipe and about 1 inch apart vertically, and sloped to direct the liquid in a circular motion. Thus the diluent is introduced under pressure simultaneously at 14 points through the concentrate.

5. A line shutoff valve attached to the outlet in the bottom of the concentrate tank and a valve on the spray boom to control the flow of spray to the nozzles.

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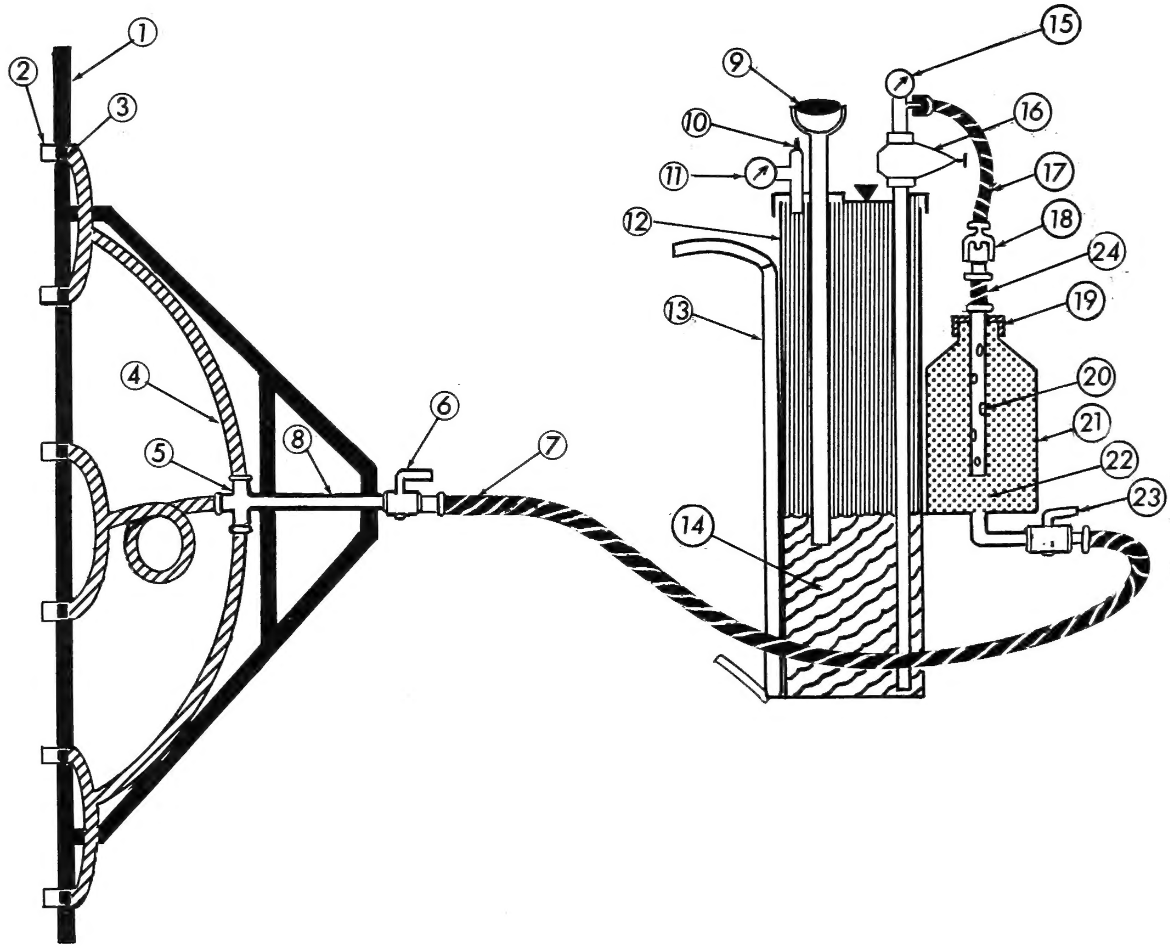
[2] Research Agronomist, Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture.

[3] Underlined figures in parentheses refer to Literature Cited at end of report.

6. A spray boom frame constructed of 1/4-inch, high-strength aluminum pipe. A three-way manifold directs spray to the nozzles through 1/4-inch inside diameter tygon tubing. The three lines are divided again equally at the boom to provide six nozzle outlets. These lines are adjustable for swaths up to 12 feet wide.

7. Six nozzles, which are quickly adjustable for swath width, attached by metal clamps to the boom.

The weight of this equipment--boom and sprayer--is approximately 20 pounds.



1. Boom frame
2. Nozzle
3. Nozzle clamp adjustable
4. Tygon tubing
5. Dividing manifold
6. Shutoff valve
7. Hose
8. Pipe, 1/4 inch dia.
9. Hand pump
10. Air chuck
11. Pressure gage
12. Air and diluent tank
13. Pack board
14. Diluent
15. Pressure gage
16. Pressure regulator
17. Hose
18. Hose coupling
19. Cap on concentrate tank
20. Mixing manifold
21. Concentrate can
22. Concentrate spray
23. Shutoff valve
24. Hose

Figure 1.--Line diagram of arrangement of parts of portable variable rate sprayer.

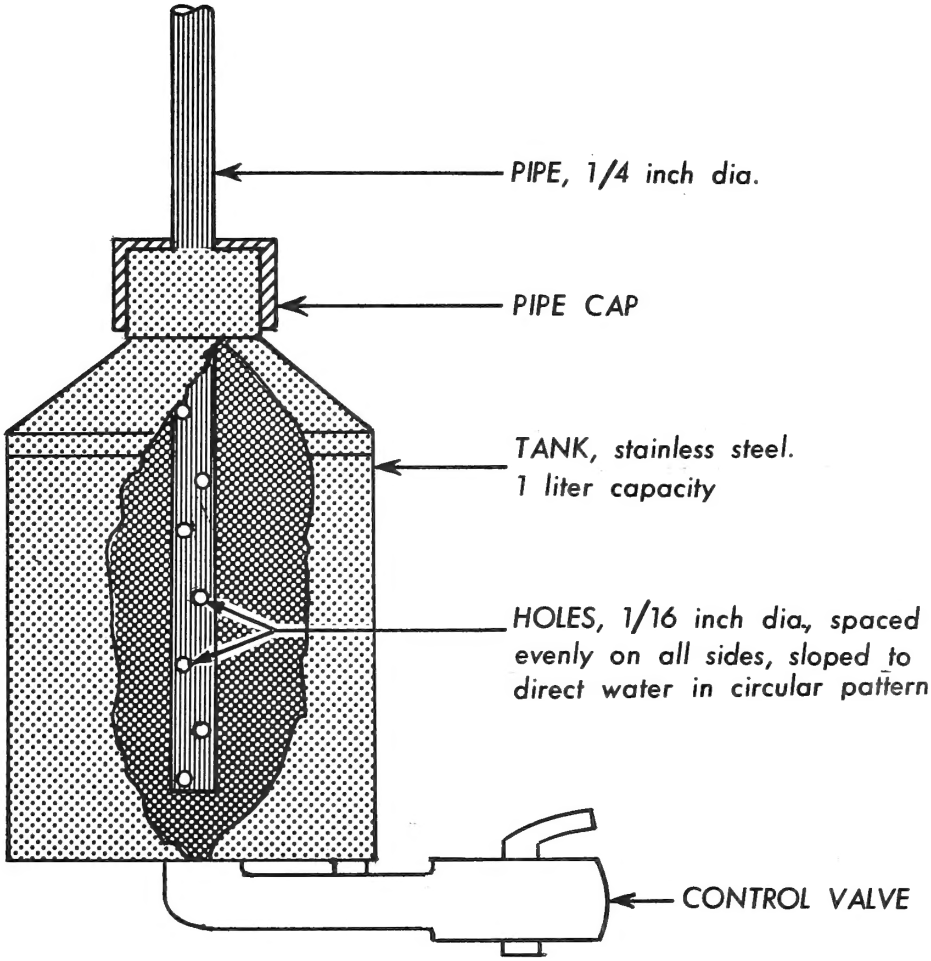


Figure 2.--Cutaway view of concent rate tank showing the mixing manifold inside.

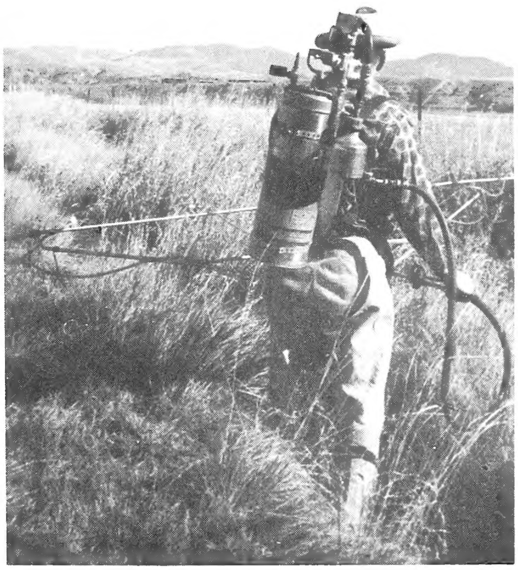


Figure 3.--A portable sprayer for applying variable dosages on experimental plots.

CALIBRATION METHODS AND RESULTS

The wheel-mounted variable-rate sprayers, as well as this portable one, employ two spray tanks to deliver the desired dosage pattern. As the spray is discharged, the diluent replaces the liquid in the concentrate tank and is mixed instantaneously with the concentrate. Thus, the dosage being delivered at any time is determined by the dilution that has occurred as the spray leaves the tank. When the solution in the concentrate tank has been diluted with an equal volume of diluent, the concentration has been halved. Actually, the dosage range in these sprayers may proceed from high to low or the reverse, depending on which tank delivers spray to the nozzle. When spray is delivered from the concentrate tank to the nozzle, the dosage begins at the highest rate and decreases at a logarithmic rate. When spray is delivered from the diluent tank, dosage begins at the lowest rate and increases. Generally, operators of these sprayers have preferred to direct the spray from the concentrate tank to the nozzle, thus proceeding from highest to lowest dosage. This latter dosage pattern has two advantages--it allows less contamination of the equipment and greater control of the range of rates.

Several trials were made with different-sized nozzles to determine the dosage pattern. A 100-p.p.m. sodium solution was used in the concentrate tank. A turntable (fig. 4) carrying 100-ml. beakers at predetermined points was rotated beneath the nozzles to obtain spray samples. The sampling points were selected after delivery from the nozzles was determined. Samples were taken of the first delivered spray and at 1, 2, and 3 half-dosage distances from the initial sample. The concentration of sodium in each sample was then determined with a flame photometer.[4]

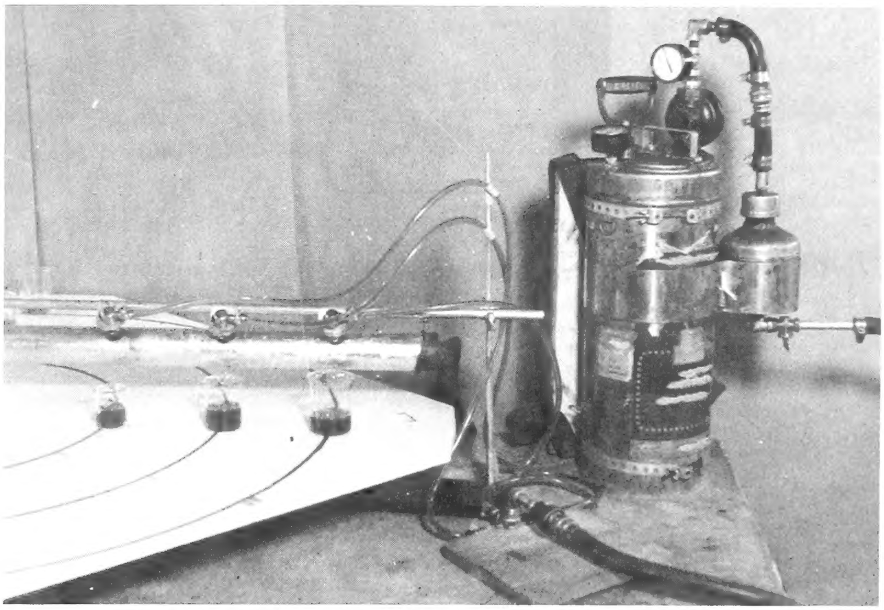


Figure 4.--Sampling dosage pattern from a variable-rate sprayer with a turntable.

[4] The help of Don Christenson, of the Agronomy and Soils Department of Montana State College, in determining these samples is gratefully acknowledged.

The dosage pattern of sodium concentrations for the initial and half-dosage positions is shown in table 1. Samples from nozzles A, B, and C, which were taken simultaneously, represent the uniformity of dosage across the sprayed swath at particular points. With few exceptions, the variation of dosage between nozzles A, B, and C was less than 2 p.p.m. for the 28 runs. Often there was no difference in samples taken simultaneously from the three nozzles in a given run. The operator of the analyses equipment felt that reading and machine errors as great as 1 p.p.m. might be expected. The average dosages for trial runs with nozzle 8008 were plotted in linear fashion on 2-cycle semilog paper (fig. 5). The line connecting the plotted concentrations is much the same as the theoretical, or computed, line; and distribution of samples falls very close to it. However, the lines diverge slightly at lower concentrations, probably because a slight error in determination of spray delivery resulted in a slight error in the theoretical line.

There was a difference of approximately 20 p.p.m. between the initial proposed concentration and that actually obtained. This was caused partly by small water droplets remaining in the lines at the beginning of each run. These lines were rinsed with distilled water after each use and blown out, but all water was not removed.

Five additional trial runs were made and the spray was sampled at 13 positions on the spray path, beginning just as the sprayer was turned on. The sodium concentrations for all three nozzles in one location were averaged (table 2). These data, plotted in figure 6, indicate that the maximum dosage is reached about 1.25 seconds after delivery of the spray begins. This dosage was about 90 percent of the calculated full-rate dosage, and the dosage decreased in a logarithmic pattern with time. Sodium concentrations were somewhat variable in positions 1 and 2 (table 2). This was caused mostly by the operator's inability to manually turn on the sprayer at precisely the same instant for each trial.

Field plots were established in 1959 and 1960 to evaluate certain promising herbicides used on sugar beets, wheat, and legume crops. The portable variable-rate sprayer was used, and characteristic logarithmic dosage patterns were obtained. The sprayer was used effectively in 1960, 1961, and 1962 in evaluating chemicals for controlling vegetation on ditchbanks, where similar wheel-mounted sprayers could not be operated.

The portable sprayer can be used also for applying fixed-rate treatments either by disconnecting the concentrate tank from the line and connecting the boom line to the diluent tank or by mixing the same dosage in both tanks.

TABLE 1.--Concentrations of sodium obtained from portable variable-rate sprayer at 4 dosage positions, Bozeman, Mont., 1961

Sample description[1]			Sodium concentration for trials--					
Elapsed time (seconds)	Rate	Nozzle position	1	2	3	4	Average	Grand average
			P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.
Nozzle 8008:								
0	Full	A	80.2	80.2	80.2		80.2	
		B	80.2	80.2	80.2		80.2	
		C	80.2	82.0	80.2		80.8	80.4
10	1/2	A	36.6	36.6	35.7		36.3	
		B	37.5	36.6	35.7		36.6	
		C	36.6	34.8	35.7		35.7	36.2
20	1/4	A	15.0	15.0	14.3		14.8	
		B	14.3	15.0	15.0		14.8	
		C	15.0	14.3	15.0		14.8	14.8
30	1/8	A	6.8	7.8	5.8		6.8	
		B	8.3	7.4	6.3		7.3	
		C	6.8	7.8	6.3		7.0	7.0
Nozzle 8006:								
0	Full	A	80.2	78.3	74.9	76.3	77.4	
		B	76.5	74.9	71.5	78.3	75.3	
		C	80.2	76.3	74.9	78.3	77.4	76.7
10.75	1/2	A	36.6	33.9	35.7	34.8	35.2	
		B	36.6	34.8	36.6	36.6	36.2	
		C	36.6	34.8	35.7	35.7	35.7	35.7
21.5	1/4	A	16.8	13.7	15.0	15.0	15.1	
		B	16.2	15.0	15.0	15.0	15.3	
		C	15.5	15.0	15.0	15.0	15.1	15.2
32.25	1/8	A	8.2	6.3	6.3	6.3	6.8	
		B	6.2	6.8	6.8	6.3	6.5	
		C	6.0	5.8	6.8	6.8	6.4	6.6

[1] Sample time and rate were calculated by delivery rate as determined in 3 trial runs.

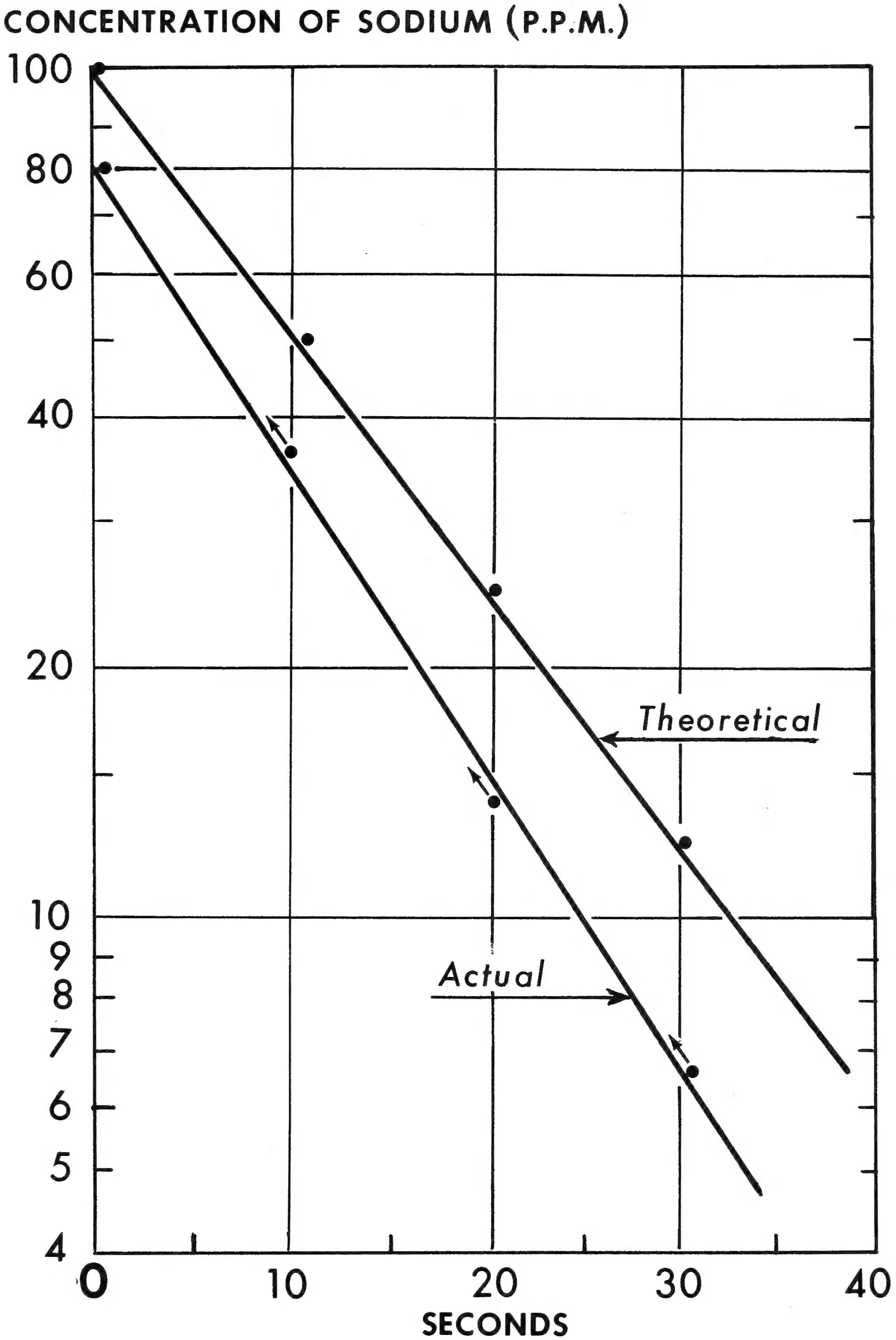


Figure 5.--Sodium concentration dosage pattern produced by variable-rate sprayer with 8008 nozzles, as compared to the theoretical concentration pattern.

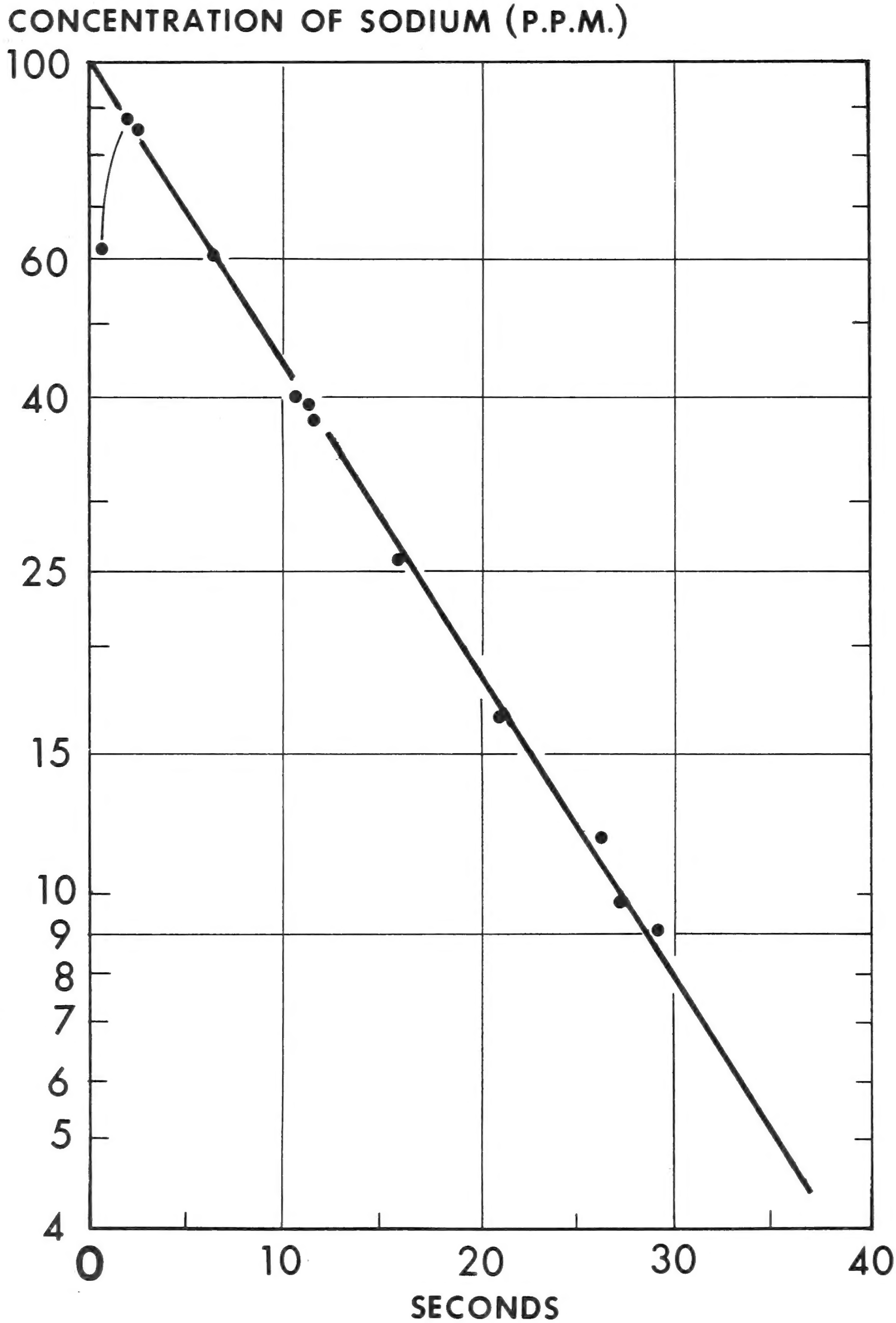


Figure 6.--Dosage pattern of variable-rate sprayer determined by sodium concentration.

TABLE 2.--Sodium concentration obtained from portable variable-rate sprayer sampled at 13 positions on the spray path

Time from first position (seconds)	Sample position	Average sodium concentration [1]
		P.p.m.
0	1	60.9
.5	2	79.3
1.0	3	87.5
1.5	4	86.9
5.4	5	59.5
10.19	6	40.3
10.68	7	39.0
10.98	8	37.2
15.65	9	25.8
21.00	10	16.6
26.15	11	11.6
27.25	12	9.9
28.29	13	9.1

[1] Average of 5 replicates.

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